There are four essential elements in materials science and engineering: (i) processing/synthesis; (ii) structure/composition; (iii) properties; and (iv) performance/application (Fig. 1.1). There is a growing realisation among scientists and engineers that in order to develop new materials and provide materials efficiently for society, all four elements need to be considered. This gives materials science and engineering its interdisciplinary nature. Nowadays, it is common (and indeed preferred in many cases) for people with different backgrounds (materials, physics, chemistry, metallurgy, ceramics, electronics, etc.) to work together to solve materials problems and to make important contributions to this field.

1.3. Materials and Electrical/Electronic Engineering

Functional materials play a very important role in almost all industries. They are often the critical component of equipment or instrumentation determining the overall performance and efficiency of the whole system. The topic of functional materials has experienced rapid growth in the last thirty years as it is among the most active discipline in modern science and engineering. New developments in functional materials, such as semiconductors, superconductors and optical fibres, are revolutionising modern society. Without these materials, modern devices, computers, automatic machines, telecommunications systems, aircraft, etc., could not exist. For example, in the automobile industry, a standard 1994 model car consisted of electronics worth more than US$800. This is more than the value of steel used in its body, frame, engine and transmission system, which cost approximately US$675.

The electronics industry is one of the most dynamic industries in the global economy. The worldwide electronic materials market, valued at US$2.5 billion, was responsible for an equipment market valued at more than US$400 billion in 1985. The electronics industry is also a leader in the use of new materials. Highly engineered materials are vital to the continued progress of the electronics industry. Strong interrelationships between device design, materials science and engineering, and process chemistry determine the performance of a device. Semiconductors are the basic materials in the electronics industry; most current devices are based on a single crystal silicon. A high-quality, single-crystal, defect-free silicon with a diameter of 150 mm is grown from the melt using a highly automated

process. Oxygen levels for gathering impurities are controlled by computer. Epitaxial growth is widely used to form devices on Si wafers, and it is also controlled by computer. The processing steps, which include masking, photolithography, etching, diffusion, ion implantation, metallisation and oxidation, largely determine the performance and quality of the devices. The development of materials and processing in the semiconductor industry allows us to produce integrated circuits with a billion components contained in each chip, thus furthering the revolution in information technology which has reshaped our society.

The telecommunications industry is another example where functional materials play an extremely important role. The shift from electronic to optical technology required the development of many new optical materials. Optical fibres have to be very transparent to transmit light signals over a long distance. The development of new process technologies has resulted in silica optical fibres with transmission losses of 100 orders of magnitude lower ($\times 10^{-100}$) than ordinary optical glasses, and which approaches the theoretical minimum. Materials based on new systems, including fluorides, are being studied in an effort to further reduce the optical losses. However, new light sources and detectors will be needed as transmission frequencies make inroads into the infrared region.

1.4. Nature and Purpose of this Book

Engineers in all disciplines should have some basic and applied knowledge of materials in order to optimise their understanding and effectiveness. This textbook provides an introductory course for electrical engineering and other engineering-technology students. Its emphasis is on the application of materials in electric, electronic and telecommunication industries. A basic understanding of the relationships between processing, structure, properties and performance provides the tools and, therefore, the main purposes are as follows:

(i) To appreciate the importance of materials in modern technology.
(ii) To understand the basic principles of electronic properties of materials.
(iii) To familiarise the reader with the various groups of materials used in electrical and electronic industries.